The Fed-Induced Political Business Cycle

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Abstract

Given that Nordhaus' political business cycle theory is relevant at election cycle frequency and that its validity can change over time, we consider wavelet analysis especially suited to test the theory. For the postwar U.S. economy, we exploit wavelet methods to demonstrate whether there actually exists an opportunistic political business cycle in monetary policy by allowing for time-varying behavior and by introducing the frequency-domain perspective. Our results indicate an inclination of the Federal Reserve to cut the Funds rate prior to presidential elections except for the 1990s. Moreover, such political manipulation is shown to significantly affect output in not only the famous Burns–Nixon era but also the Volcker–Reagan era. The outcomes are robust even when the effects of government spending are controlled for.

JEL classifications: E52; E58

Keywords: Monetary policy; Political business cycle; Wavelet

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1 Introduction

To date, a large literature has addressed issues of central bank independence on various aspects, also referred to as freedom of monetary policies from various political factors (e.g., Frey and Schneider, 1981; Alesina and Summers, 1993; Acemoglu et al., 2008; Jones and Snyder, 2014).[1] In particular, most would concur on the importance of elections as one of the most crucial factors affecting central bank independence.

In an influential article published in 1975, William Nordhaus presented the opportunistic political business cycle theory. In his framework, policymakers manipulate macroeconomic policies to get themselves re-elected, and consequently macroeconomic fluctuations follow the election cycle. The most famous case relates to the historical political business cycle in the 1972 U.S. presidential elections of the Burns–Nixon era. Backed up by personal tape recordings, Abrams and Butkiewicz (2012) document that Arthur Burns and the Federal Reserve introduced an excessively expansionary monetary policy following Richard Nixon's insistent pressures prior to the 1972 election. As a result of the monetary easing that followed, the unemployment rate fell and inflation accelerated.

Since Nordhaus' (1975) seminal work, numerous authors have attempted to systematically test the existence of opportunistic political business cycles (e.g., Allen and McCrickard, 1991; Alesina and Roubini, 1992; Alesina et al., 1992). However, Alesina et al. (1992, p. 227) state that "the empirical literature generated by the Nordhaus paper yielded, at best, mixed results." This situation remains the same even today, although an extensive literature is devoted to the detailed examination of political business cycles in the aftermath of Nordhaus' work (e.g., Alesina et al., 1997; Faust and Irons, 1999; Abrams and Iossifov, 2006; Grier, 2008). All told, as Abrams and Butkiewicz (2012) mentioned, there seems to be no consensus on the validity of Nordhaus' hypothesis.

Unless there exists proof such as the personal tape recordings mentioned above for other periods as well, we have to resort to some econometric methodologies to determine such issues. To the author's knowledge, earlier studies on the topic, almost without exception, assumed regression models with election dummies included as an independent variable. In any case, while our predecessors have tried various control variables from different perspectives, we cannot find an appropriate model. The failure to control for important factors can lead to bias in regressions. For example, an omitted variable bias could be one reason for the mixed results in the empirical

[1] For theoretical analyses related to central bank independence, see, for example, Rogoff (1985), Beetsma and Bovenberg (1997), McCallum (1997), and Weymark (2007). A more detailed survey on central bank independence can be found in Walsh (2003).

literature.

In order to resolve this unsettled question, we employ wavelet analysis to examine the political business cycles in monetary policy for the postwar U.S. economy. In comparison with the various regression analysis methods inherent in the empirical literature, our method has mainly two advantages. First, it enables us to decompose the election cycle components by frequency by using the difference in frequency bands between election and business cycles.[2] The primary advantage is that the possibility of some estimation bias accompanying the regression approach can be avoided. Second, because wavelets permit economic variables to change locally over time at each periodic component, we can avoid the necessity of selecting the sample period. Consequently, the present approach provides a comprehensive evaluation of previous studies that target different periods and fail to reach a consensus.

Our wavelet procedure empirically supports Nordhaus' political business cycle model, in particular relating to presidential elections in the United States. To be more precise, our contribution can be summarized as follows: (a) We show that the monetary policy is expansionary prior to presidential elections except for the 1990s, meaning that generally monetary policy is not independent of politics; this result provides new insights into the empirical literature wherein heterogeneous outcomes on the existence of opportunistic monetary cycles create confusion. (b) We also show that such political manipulations significantly affect output in not only the famous Burns–Nixon era but also the Volcker–Reagan era. In other words, we find that the political business cycle in these two periods is actually induced by the Fed. For the former period, the outcome is consistent with Abrams and Butkiewicz (2012) and offers formal evidence. The results for (b) are robust even when the effects of government spending are controlled for.

The paper is structured as follows. The next section explains our empirical strategy for identifying opportunistic political business cycles in more detail after reinterpreting the basic theory of Nordhaus (1975) from an empirical standpoint. Section 3 presents our wavelet results. Section 4 concludes the paper.

2 The opportunistic political business cycle

2.1 The basic theory and empirical strategy

Before detailing our empirical strategy, we outline the empirical implications of Nordhaus' (1975) model. Aside from various other models, his theory stands fun-

[2]Except for Funashima (2013), who uses a band-pass filter to identify the Fed's behavior toward presidential elections, no attempts have been made to examine such frequency-domain perspectives introduced in the context of the U.S. political business cycle.

damentally behind the present analysis.[3] The underlying assumptions can be summarized as follows.[4]

First, the model economy is described by the following Phillips curve:

$$\xi \;=\; f(u) + \lambda \xi^e, \quad 0 < \lambda \le 1, \tag{1}$$

where ξ stands for inflation, ξ^e the expected inflation, and u unemployment, and f satisfies the usual conditions so that $f' < 0$. Second, the expected inflation is adaptive:

$$\dot{\xi}^e \;=\; \gamma(\xi - \xi^e), \quad \gamma > 0. \tag{2}$$

Third, policymakers choose the level of inflation or unemployment and maximize the vote function:

$$V \;=\; \int_0^\theta g(u, \xi) e^{\mu t} dt, \tag{3}$$

where $\theta(> 0)$ is the length of the electoral period, μ the rate of decay of voters' memories such that it takes positive values ($\mu > 0$), and g the vote function in the static case satisfying the usual conditions (i.e., $V_u < 0$ and $V_\xi < 0$). In summary, the incumbent's optimization problem is to maximize (3) subject to (1) and (2).

To solve this problem explicitly, we specify the functional forms. For example, Nordhaus assumes the following specification:

$$f(u) \;=\; \alpha_0 - \alpha_1 u,$$

so that the Phillips curve is

$$\xi \;=\; \alpha_0 - \alpha_1 u + \lambda \xi^e.$$

Furthermore, he assumes that

$$g(u, \xi) \;=\; -u^2 - \beta \xi, \quad \xi \ge 0, \quad \beta > 0,$$

and hence the dynamic optimization problem is shown to maximize

$$V \;=\; \int_0^\theta (-u^2 - \beta \xi) e^{\mu t} dt,$$

[3]Nordhaus' initial model has been refined by some authors (see, e.g., Rogoff, 1990). For a brief review of the development in the literature, see, for example, Alesina and Roubini (1992). More recently, Milani (2010) studies several political cycle models in a New Keynesian framework.

[4]In what follows, the time variable is omitted when not needed for clarity.

subject to

$$\dot{\xi}^e = \gamma \left\{ \alpha_0 - \alpha_1 u - (1-\lambda)\xi^e \right\}.$$

Solving the optimization problem yields the following optimal policy:

$$u^* = \left(\frac{\beta \alpha_1}{2} + \frac{B}{A} \right) \exp\left\{ A(t-\theta) \right\} - \frac{B}{A}, \tag{4}$$

where $A = \gamma(1-\lambda) - \mu$ and $B = -\alpha_1\beta(\gamma - \mu)/2$. From (4), we see that this model generates political business cycles under certain parameter settings.

Note importantly that the resultant business cycle path depends on the parameter values, and that the shape is not necessarily saw-toothed as depicted by Nordhaus (1975, Figure 8). It is highly probable that the path changes over time in reality. In an extreme case, for example, if $A = 0$, then u^* is independent of time. In this case, no political business cycle occurs even if policymakers manipulate their macroeconomic policies to maximize the above vote function. Moreover, even if the parameters are stable over time, there is no reason a priori for every incumbent policymaker to follow the same policy.[5]

In addition to these time-varying possibilities, we need to note that the timing of elections is exogenously fixed and that political business cycles occur at particular frequencies. In other words, the spectrum of output series resembles that in Figure 1. In the U.S. case, the interval of presidential elections θ is de jure determined to be strictly 4 years. Overall, the election cycle is more frequent than the business cycles, from the National Bureau of Economic Research's business cycle dates. While the duration of the business cycle is uneven, the election cycle takes strictly 4 years to complete.[6] Hence, it is useful to decompose the election cycle component by frequency to identify the political business cycle.

Motivated by the two aspects, we use one of the wavelet (time-frequency) analyses developed recently, namely, continuous wavelet analysis. As shown below, the wavelet method enables us to examine how the economic variables interact at various

[5]Tempelman (2007) points out that the Fed is more independent of presidential elections in the Volcker–Greenspan era than in the earlier period.

[6]One may view the Olympic Games as another crucial factor occurring every 4 years, because they are held the same year of the U.S. presidential elections. In our sample period, since 1994, the summer and winter Olympic Games are held alternately every 4 years, and only the summer Olympic Games occur the same year of the elections. While no empirical attempt is made in the United States in this regard, the effect on GDP depends on whether the games are held at home or overseas. In the case of overseas Olympic Games, it is conceivable that they have negligible effects on the United States. Even if the domestic Olympic Games increase government spending and have a significant impact on GDP, the cycle of effects cannot be specified. In our empirical work, as a precautionary measure, we use partial wavelet analysis to exclude these effects of government spending.

frequencies and how their relationship changes over time.

2.2 Wavelet method

Following Aguiar-Conraria et al. (2012) and Aguiar-Conraria and Soares (2014), we summarize our wavelet method.

To begin with, we consider the univariate case of a time series $x(t)$. The continuous wavelet transform for a mother wavelet ψ is given by

$$W_x(\tau, s) \quad = \quad \int_{-\infty}^{\infty} x(t)\tilde{\psi}^* \left(\frac{t-\tau}{s}\right) dt, \quad s, \tau \in \boldsymbol{R}, s \neq 0, \tag{5}$$

where s is the scaling factor determining wavelet length and concerns frequency, τ is the translation parameter representing the wavelet location in time, and the asterisk denotes complex conjugation. Wavelet daughters $\tilde{\psi}$ are defined as scaling and shifting the mother wavelet ψ:

$$\tilde{\psi}_{\tau,s}(t) = \frac{1}{\sqrt{|s|}}\psi\left(\frac{t-\tau}{s}\right). \tag{6}$$

If the absolute value of s is less than 1, the wavelet is compressed. Conversely, if the absolute value of s is more than 1, the wavelet is stretched.

All wavelet measures described below are based on this transform. A comparison between the Fourier transform and wavelet transform may be useful to interpret (5). A crucial difference between them is that the former depends only on frequencies whereas W_x depends on time as well as frequencies. Hence, we can capture the changing behavior of each periodic component by using the wavelet transform.

We now lay out the functional form of the wavelet. As in Aguiar-Conraria et al. (2012), Rua (2012), Aguiar-Conraria and Soares (2014), Marczak and Gómez (2015) and many others, we assume the Morlet wavelet of the form

$$\psi_{\omega_0}(t) \quad = \quad \pi^{-1/4}\left(e^{i\omega_0 t} - e^{-\omega_0^2/2}\right)e^{-t^2/2},$$

where i is an imaginary unit (i.e., $i = \sqrt{-1}$). If $\omega_0 \geq 5$, the unit is approximately equal to

$$\pi^{-1/4}e^{i\omega_0 t}e^{-t^2/2}. \tag{7}$$

By comparing this representation with the Fourier transform case, one can see their difference again. The Fourier's basic wave has a permanent length of the form

$$e^{i\omega t} = \cos(\omega t) + i\sin(\omega t),$$

where the corresponding waves in (5), $\tilde{\psi}\{(t-\tau)/s\}$, are localized around τ, with the length depending on s. In other words, while any time series consists of trigonometric waves in the Fourier case, the wavelet in (7) is enveloped by a Gaussian function.[7]

From the above wavelet transform $W_x(\tau, s) = |W_x(\tau, s)|(\cos\rho_x + i\sin\rho_x)$, we obtain two pieces of valuable information. First, from the amplitude of the wavelet transform $W_x(\tau, s)$, we obtain the wavelet power spectrum

$$WPS_x(\tau, s) \quad = \quad |W_x(\tau, s)|^2,$$

which differs from the classic power spectrum based on the Fourier transform and indicates how the strength of the time series $x(t)$ is distributed in the frequency domain as well as time domain.

Second, we obtain the phase angle of the wavelet transform as

$$\rho_x(\tau, s) \quad = \quad \tan^{-1}\left[\frac{\mathrm{Im}\{W_x(\tau, s)\}}{\mathrm{Re}\{W_x(\tau, s)\}}\right]$$

where $\mathrm{Re}(W_x)$ and $\mathrm{Im}(W_x)$ denote the real and imaginary parts of the wavelet transform W_x, respectively. The phase angle is useful to examine whether the time series $x(t)$ rises or falls.

Turning now to the bivariate case, we assume $x(t)$ and $y(t)$ to denote two time series of interest respectively. To evaluate the relationship between the two series, for each wavelet transform we consider the cross wavelet transform

$$W_{xy}(\tau, s) \quad = \quad W_x(\tau, s)W_y^*(\tau, s).$$

Thus, we define the complex wavelet coherency as

$$\Gamma_{xy}(\tau, s) \quad = \quad \frac{S(W_{xy}(\tau, s))}{\sqrt{S(|W_{xx}(\tau, s)|)S(|W_{yy}(\tau, s)|)}},$$

which represents the normalized covariance between $x(t)$ and $y(t)$, where S is a smoothing operator in time and frequencies. Moreover, from the amplitude $|W_{xy}(\tau, s)|$, we obtain the wavelet coherency

$$R_{xy}(\tau, s) \quad = \quad \frac{|S(W_{xy}(\tau, s))|}{\sqrt{S(|W_{xx}(\tau, s)|)S(|W_{yy}(\tau, s)|)}}. \tag{8}$$

[7]The Morlet wavelet is one of the most widely used mother wavelets. We assume that $\omega_0 = 6$, as in Aguiar-Conraria et al. (2012) and many other studies, because, when $\omega_0 = 6 \simeq 2\pi$, we obtain a tractable relationship between frequencies f and the scaling factor (i.e., $f \simeq 1/s$). Incidentally, in this wavelet, the optimal joint time-frequency concentration can be attained in that the so-called Heisenberg box area is the minimum value. See, for example, Aguiar-Conraria and Soares (2014) for more details on the association with the so-called Heisenberg uncertain principle.

Note that wavelet coherency is akin to correlation coefficients, and we can interpret it as a localized correlation coefficient over time, reflected by τ, and across frequencies, reflected by s. Note also that since $R_{xy}(\tau, s)$ is calculated as absolute value, it cannot be less than 0 or more than 1 (i.e., $0 \leq R_{xy}(\tau, s) \leq 1$).

From the phase angle of the cross wavelet transform, $\rho_{xy} \in [-\pi, \pi]$, the phase difference can be expressed as

$$\begin{aligned} \rho_{xy}(\tau, s) &= \rho_x(\tau, s) - \rho_y(\tau, s) \\ &= \tan^{-1}\left[\frac{\mathrm{Im}\{W_{xy}(\tau, s)\}}{\mathrm{Re}\{W_{xy}(\tau, s)\}}\right]. \end{aligned}$$

Following Aguiar-Conraria et al. (2012), we summarize the various possibilities of ρ_{xy} as follows. When $\rho_{xy} \in (-\pi/2, \pi/2)$, x and y move in phase. In particular, if $\rho_{xy} = 0$, x and y move exactly together; if $\rho_{xy} \in (0, \pi/2)$, x leads y; and if $\rho_{xy} \in (-\pi/2, 0)$, y leads x. On the other hand, when $\rho_{xy} \in (\pi/2, \pi]$ or $\rho_{xy} \in [-\pi, -\pi/2)$, x and y move out of phase. In particular, if $\rho_{xy} = \pi$ or $\rho_{xy} = -\pi$, they move in anti-phase; if $\rho_{xy} \in (\pi/2, \pi)$, y leads x; and if $\rho_{xy} \in (-\pi, -\pi/2)$, x leads y.

In the present analysis, fiscal policies might affect both output and monetary policy at each periodic component. Hence, we need to eliminate such fiscal policy effects. To this end, we use the partial wavelet coherency and partial phase difference proposed by Aguiar-Conraria and Soares (2014).[8] We now consider the case in which there are three variables, x, y, and z. Our interest is in the relationship between x and y, while z affects both x and y. In analogy with partial correlation, the complex partial wavelet coherency of x and y after eliminating the effects of z on them is defined as

$$\Gamma_{xy\cdot z}(\tau, s) = \frac{\Gamma_{xy} - \Gamma_{xz}\Gamma_{yz}^*}{\sqrt{(1 - R_{xz}^2)(1 - R_{yz}^2)}}.$$

From the absolute value of $\Gamma_{xy\cdot z}$, we have the partial wavelet coherency

$$R_{xy\cdot z}(\tau, s) = \frac{|\Gamma_{xy} - \Gamma_{xz}\Gamma_{yz}^*|}{\sqrt{(1 - R_{xz}^2)(1 - R_{yz}^2)}},$$

which can be interpreted as a localized partial correlation over time and across frequencies. From the angle phase of $\Gamma_{xy\cdot z}$, the partial phase difference can be represented as

$$\rho_{xy\cdot z}(\tau, s) = \tan^{-1}\left[\frac{\mathrm{Im}\{\Gamma_{xy\cdot z}(\tau, s)\}}{\mathrm{Re}\{\Gamma_{xy\cdot z}(\tau, s)\}}\right].$$

[8] The partial wavelet procedure is useful to eliminate the effects of the Olympic Games as well as fiscal manipulation on elections. See footnote 6 for more details.

3 Data and empirical results

3.1 Data

Our data comprise quarterly observations on output growth and monetary and fiscal policy instruments. As proxy variables of the respective observations, following most of our predecessors in the empirical literature, we use the growth of real GDP, the Federal Funds rate (FFR), and growth of real government spending. All data are obtained from the St. Louis Fed FRED website. Our sample period extends from 1954:3 to 2008:3. The ending date of the sample period is limited by the zero lower bound on the FFR.

3.2 Empirical results

In this section, we report the wavelet results and accomplish two main objectives. First, we examine the opportunistic monetary cycle, a necessary condition for the political business cycle. Second, we identify the period of the political business cycle. In doing so, we numerically compute the above-mentioned wavelet measures by using the ASToolbox provided by Luis Aguiar-Conraria and Maria Joana Soares.

To investigate the existence of opportunistic monetary cycles, we first examine the phase angle of the FFR, ρ_x, where x is the FFR. Figure 2 plots the presidential election phase of the FFR, whose cycles are between 3.9 and 4.1 years. In the figure, the shaded area represents the presidential election years. With the vertical axis representing the phase angle, we find that monetary easing emerges prior to the election years except for the 1990s.

In closely related work on the United States, Abrams and Iossifov (2006) and Funashima (2013) suggest that the Fed is relatively expansionary before elections from 1954 through 2004. On the other hand, Tempelman (2007) casts a doubt on their suggestions over the long period and points out the possibility of such political monetary cycles not being true in terms of the Volcker–Greenspan period from 1979 to 2004. In this connection, Clarida, Galí, and Gertler (2000) also indicate that the Fed responds more systematically to inflationary deviations and GDP gaps in the Volcker–Greenspan period than in the pre-Volcker period.

Our results provide a qualitative interpretation of the discrepancy in the literature. That is, at the minimum, the stability of parameters in the estimated periods in those works is debatable, and Tempelman's (2007) opinion appears justified for a more limited period (i.e., the 1990s). Of course, the key insights obtained from our wavelet procedure stem from the changing behavior of the FFR at election cycle frequency. Abrams and Iossifov (2006), Clarida, Galí, and Gertler (2000), and many others estimate certain policy reaction functions through regression analysis, wherein they are forced to assume that the coefficients are stable over a certain sample period in order to obtain precise estimates. In an exceptional move, Funashima (2013) examines the Fed's behavior using not a regression approach, but a band-pass filter method, which fundamentally relies on the Fourier analysis, but cannot capture the time-varying behavior at each periodic component, as already discussed in the preceding section. On the other hand, in our empirical work, the wavelet tools permit us to relax these assumptions and allow for the behavior of the FFR to vary locally over time at election cycle.

In our next step, we examine whether those political monetary cycles affect output. Figure 3 shows the phase difference ρ_{xy} and wavelet coherency R_{xy}, where x is the GDP and y the FFR. The phase difference is calculated at frequencies between years 3.9 and 4.1 per cycle as before. We expect the range of phase difference to be between $\pi/2$ and π. This is because a negative relationship would arise between them if the FFR affects GDP, with the FFR leading. When assessing the statistical significance of wavelet coherency, we run Monte Carlo simulations such that surrogate series are generated by the fitted ARMA (1, 1) model with errors from a Gaussian distribution.

In Panel A of Figure 3, as expected, the phase difference is between $\pi/2$ and π on the whole, revealing that monetary easing (tightening) results in a rise (fall) in output with time lags at election frequency. Considering the above findings in Figure 2, we conclude that policymakers nurture an opportunistic political business cycle through monetary policy manipulations, except for the 1990s under the Greenspan regime.

Note, however, that the extent to which the political manipulation effects of monetary policy impact output is open to debate. To evaluate the aftermath of the political monetary cycle formally, we explore the wavelet coherency. From a simple visual inspection of Panel B of Figure 3, we find two periods of high coherency at election frequency (4 years), both of which are statistically significant at the 0.05 level. The first period is located approximately between the two election terms (from 1968 to 1976) and includes the 1972 election under the Burns–Nixon regime. The implication of the result is consistent with Abrams and Butkiewicz (2012). More surprisingly, the second period encompasses the 1984 election under the Volcker–Reagan regime. Note that the evidence of the second period is new in the empirical literature.

Up to this point, we did not consider the interdependence of fiscal policy. This leaves open the possibility of imprecise outcomes due to the failure to control for fiscal manipulations at election cycle frequency. In an attempt to assess the robustness of the above outcomes, we explore the partial phase difference and partial wavelet coherency excluding the effects of fiscal policy on output and monetary policy.

Figure 4 shows the results of $\rho_{xy\cdot z}$ and $R_{xy\cdot z}$, where x is the GDP, y the FFR, and z government spending. For the statistical significance of wavelet coherency, we conduct Monte Carlo simulations as before. For the most part, these results reinforce our above findings. In Panel A of Figure 4, except for the partial phase difference exhibiting unstable behavior in the early 1990s, the same patterns are obtained as before. Disregarding all frequencies outside the 4-year election cycle, in Panel B of Figure 4, only the 1972 and 1984 election periods are once again encompassed in the significant regions.

We complete our robustness analysis by reassessing the different band widths including the 4-year election cycles. In order to do this, we reevaluate the wavelet tools by slightly and variously replacing the benchmark frequency band interval (from 3.9 to 4.1 years) with other values. As a result, regardless of univariate phase angle or bivariate or partial phase difference, we obtain almost the same results. In other words, all the qualitative features of our benchmark results on phase seem to hold here as well, and they are largely robust.

While acknowledging the difficulty in identifying the occurrence factors, our wavelet results nonetheless reveal a common pattern of the two elections: the incumbent presidents (Nixon and Reagan) were re-elected under Republican administrations. This can be straightforwardly interpreted as confirming Nordhaus' (1975) predictions. However, although the 2004 elections presented a similar situation, we do not find a significant political cycle in that period. In summary, while we confirm that we do not observe an opportunistic monetary cycle in the 1990s in the first place, the central bank's independence is relatively strengthened in the last three decades.

4 Conclusion

Since Nordhaus' political business cycle theory is relevant at election cycle frequency and its validity can change over time, we consider wavelet analysis especially suited to test the theory. In this study, we used wavelet techniques to examine the opportunistic political business cycle in monetary policy for the postwar U.S. economy. In doing so, we shed new light on the empirical literature.

One of the most notable results of this study is that we identify the periods when Nordhaus' predictions are valid for nearly half a century. More specifically, after the empirical characterization of the political monetary cycle, we provide the first evidence confirming Nordhaus' predictions in the 1984 election of the Volcker–Reagan era as well as formal evidence confirming his predictions in the 1972 election of the Burns–Nixon era. Arguably, such definitely specified periods cannot be uncovered through some regression or classic time-series analysis.

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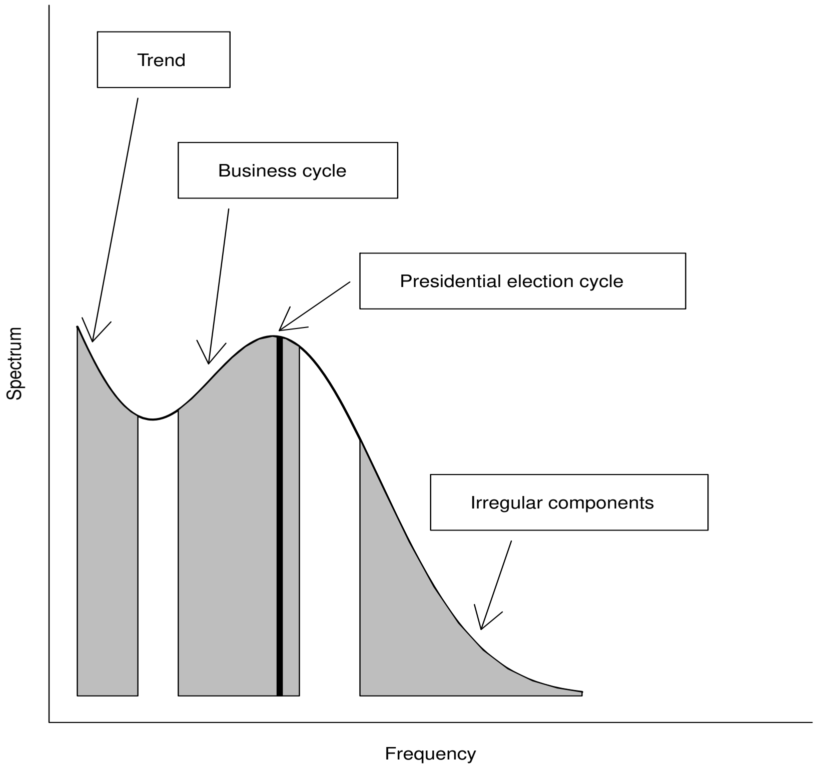

Figure 1: Spectrum of Output Series

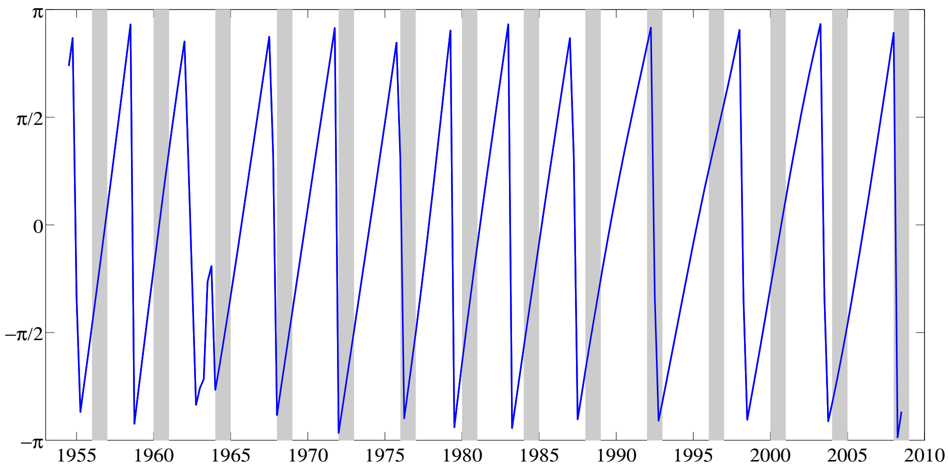

Figure 2: Presidential Election Phase of FFR

Notes: The shaded area represents the presidential election years.

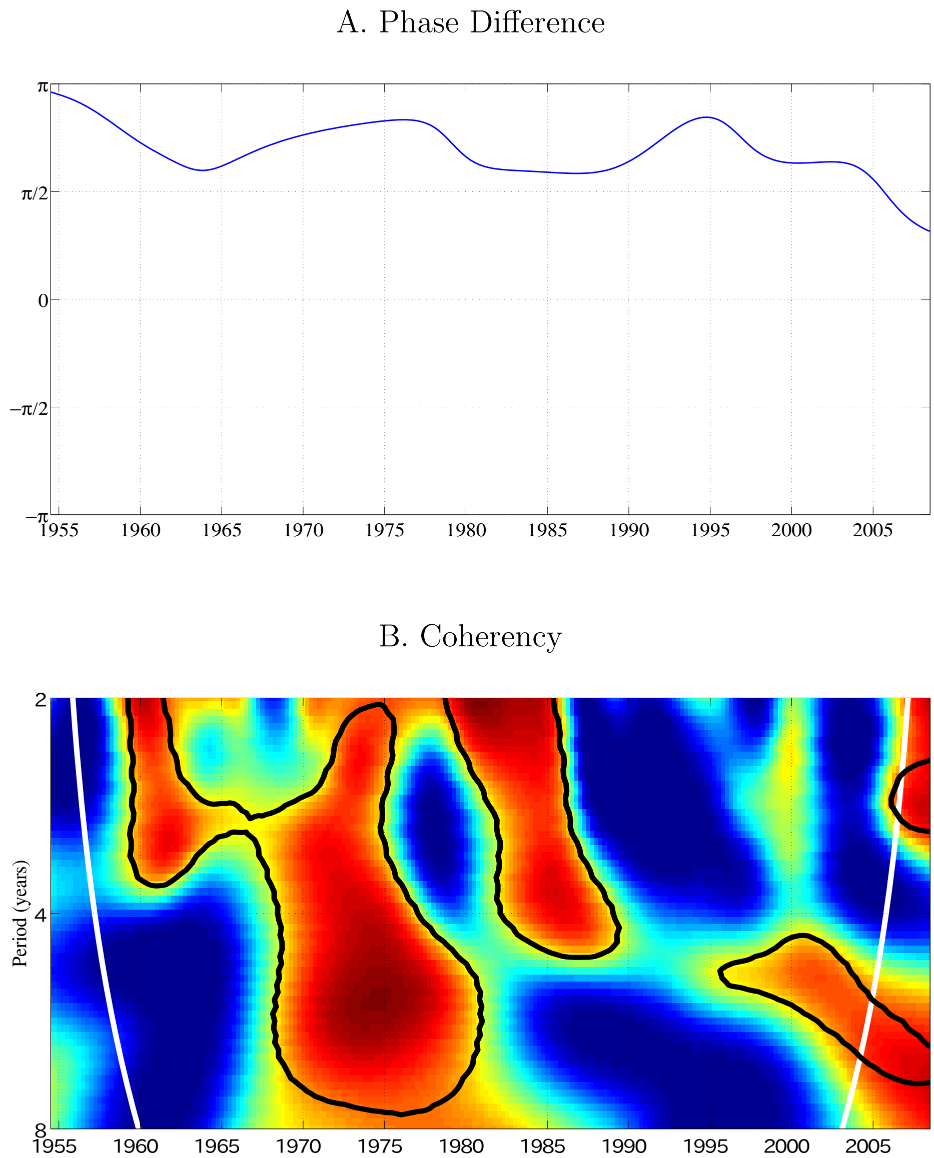

Figure 3: Coherency and Phase Difference between GDP and FFR

Notes: In Panel B, the black contours represent the 5% significance level. The white line represents the cone of influence.

A. Phase Difference

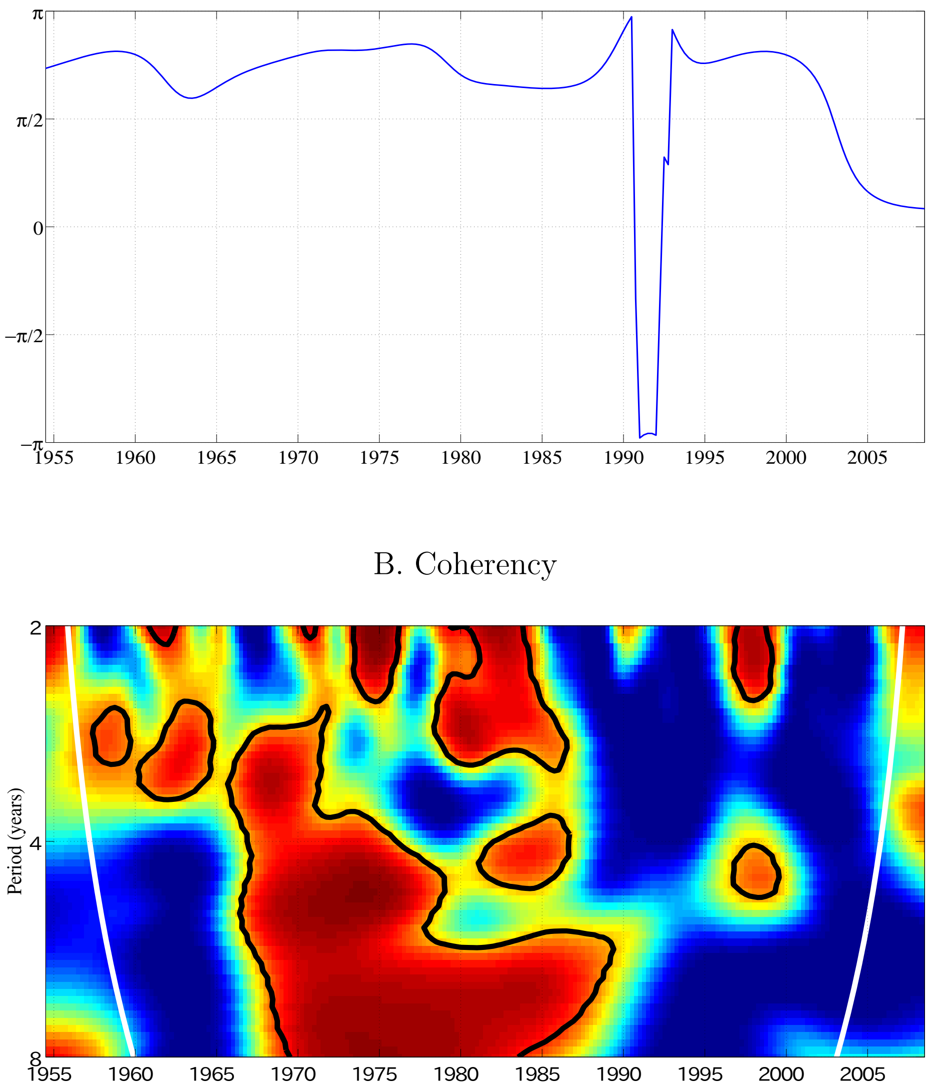

Figure 4: Partial Coherency and Phase Difference between GDP and FFR after Controlling for Government Spending

Notes: In Panel B, the black contours represent the 5% significance level. The white line represents the cone of influence.